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HPCBS

High Performance Commercial Building Systems

Report on Initial Energy Simulations

Element 6 – Indoor Environmental Quality

Project 2.1 – Energy Simulations and State-Wide Energy Savings

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Report on Initial Energy Simulations.

The report on the following pages, submitted to LBNL under contract by Davis Energy Group, presents the initial DOE-2.1E energy simulations of the "Package B" Relocatable Classroom as defined in the HPCBS Element 6 Scope of Work.

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HPCBS Element 6, Project 2.1: Relocatable Classroom DOE-2 Analysis Report

Report Issued: January 3, 2002

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Executive Summary

Program Element 6 of Lawrence Berkeley National Laboratory's High Performance Commercial Building Systems (HPCBS) PIER program includes a task to complete a DOE-2 evaluation of relocatable classrooms. Simulations were completed to compare energy consumption of high performance and typical relocatable classroom designs in four climate zones and two occupancy scenarios. High performance improvements included:

- Wall insulation R-value increased from R-11 to R-13
- Floor insulation R-value increased from R-11 to R-19
- Grey tint windows replaced with selectively coated glass
- White roof coating added to bare metal roof
- Lighting reduced from 1.66 to 0.75 W/ft²
- SEER 10 wall mount heat pump replaced by two-stage evaporative cooler and variable speed hydronic air handler with wall mount boiler

Simulations were completed for California Climate Zones 4, 11, 12, and 13. Occupancy assumptions corresponding to both traditional and year-round attendance schedules were applied.

Annual source energy savings per classroom for the high performance relocatable classroom averaged 31.3 million Btu per year, or 56% compared to the typical classroom. At fixed electric rates of $0.14 per kWh and natural gas rates of $.60 per therm, annual operating cost savings averaged $502, or 66% compared to the typical classroom. When compared against standard relocatable classrooms operating with the state mandated ventilation rate of 15 CFM/person, average source energy savings and cost savings of the high performance classrooms rise to 68% and $784, respectively.

Non-energy benefits of the high performance relocatable design include reduced noise and improved indoor air quality. Simulation results are being verified by field tests currently in progress. Clearly, the operation schedules employed by the classroom teachers in the field will affect the actual energy usage.

1 Background and Objectives

This report addresses the results of energy performance simulations completed under Program Element 6 of Lawrence Berkeley National Laboratory's High Performance Commercial Building Systems (HPCBS) PIER program. The purpose of the Energy Simulations and Projected State-Wide Energy Savings project is to develop reasonable energy performance and cost models for high performance relocatable classrooms (RC's) across California climates. The objective of the simulation work described in this report is to quantify both energy and dollar savings for the RC packages compared to standard RC construction.

The HPCBS RC energy efficiency implementations are based upon earlier work by Davis Energy Group with Pacific Gas and Electric Co. (PG&E) which culminated in the PG&E Premium Efficient Relocatable Classroom (PERC) program (DEG, 1997). The envelope energy efficiency measures selected for the HPBCS project are similar to the PERC Package 1 with the exception that the roof has a white ("Cool Roof") coating and there is no radiant barrier in the ceiling. In addition to the standard wall-mount heat pump system the HPCBS RC's have an Indirect/Direct Evaporative Cooler (IDEC) which provides heat using a gas-heated hydronic coil.

Simulations described in this report will be repeated in program year 3 after energy and IAQ field studies are completed. The data from the field studies will be used to improve model inputs and assumptions so that the DOE-2 simulations can be refined. The refined simulations will be used to provide improved statewide energy savings and predicted energy usage for both standard and improved RCs.

2 Building Description

School districts purchase RCs either as part of a new school (the state requires 20% of new classrooms to be relocatable in order to be eligible for funding (CA, 1976)), or to provide added class space to existing schools due to population growth or mandated class size reduction (CA, 1999). The majority of RCs in California are either 24' × 40' or 30' × 32' modular structures consisting of two or three modules or "floors" respectively. The modules are factory-built and then trucked individually to the site where they are assembled together. The necessity of highway transportability imposes certain design constraints such as maximum height and width, and structural integrity. Each RC design must be certified by the Division of the State Architect (DSA) for structural integrity and they must meet Title-24 non-residential energy standards (DSA, 1999). However, until recently, RC manufacturers have not had to revise their currently certified DSA plan sets to meet revised Title 24 standards. The RC base case modeled in this report reflect existing DSA plans.

2.1 Envelope

The RCs used in the HPCBS study are a standard 24' × 40' modular classroom consisting of two 12' × 40' rigid steel frame modules connected together along the long axis (see Figure 1). Each classroom has one 4' x 8' metal frame window on each end and a 6'8" x 3' insulated steel door at one end. The walls are framed in wood on 16" centers and covered with T-111 plywood siding on the outside and architectural fabric covered gypsum board on the inside. The roof consists of a single slope of standing-seam roofing on metal purlins with a dropped T-bar ceiling at 8'6" (see Figure 2). The floor is plywood set over metal purlins and covered with carpet. The walls, floor and roof are insulated with fiberglass batts. The floor insulation is covered with a membrane to protect it during transportation and installation. The roof insulation is installed against the underside of the standing-seam roof panels between the metal purlins. The 20” steel perimeter roof beam is not insulated in the base case.

2.2 Lighting

Lighting consists of 12 2’×4’ recessed fluorescent troffers with prismatic lenses set in the ceiling grid and a single fluorescent vapor-jar outside the door. The base case fixtures have 4 T12 lamps with a magnetic ballast while the HPCBS building fixtures have 2 T8 lamps with an electronic ballast and a specular reflector.

2.3 Mechanical

The base case HVAC system consists of a wall-mounted heat pump with two ceiling supply diffusers and a through-the-wall return. The unit is rated at 10 SEER[1] and 6.8 HSPF[2] and has a fixed outside air damper which is set to 15 cfm per person. 10 kW of strip heat is assumed for use during pick-up, defrost, and periods when heat pump capacity is low due to low outdoor temperatures.

The HPCBS cooling system consists of a wall-mounted indirect-direct evaporative cooler (IDEC) with three ceiling supply diffusers and two through-the-wall gravity relief dampers. Heating for the HPCBS RC is provided by a wall-mounted 85% efficient instantaneous gas water heater which supplies hot water to a hydronic heating coil in the supply plenum. 100% outside air is supplied by a variable speed fan which delivers a minimum of 15 cfm per person at all times.

All ducting is run using insulated flex-duct in the plenum space between the T-bar ceiling and the roof, so ducting is within the conditioned space of the building.

[1] Seasonal Energy Efficiency Ratio
[2] Heating Seasonal Performance Factor

Figure 1: RC Plan View

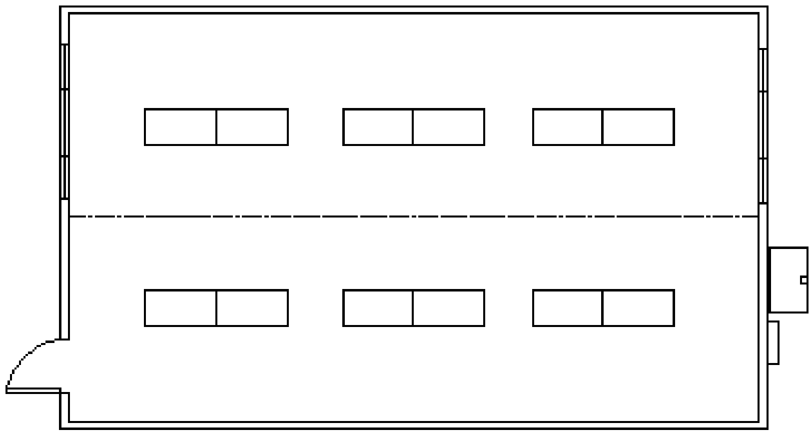
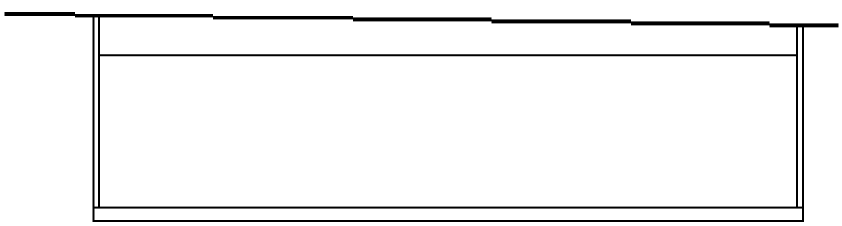


Figure 2: RC Section



3 Simulation Methods

3.1 Analysis Cases

Four different RC envelope / HVAC system configurations were modeled using DOE-2.1E (Buhl, 1993). The base case consisted of the standard envelope with the standard heat pump HVAC system and fan operation set to cycle on with compressor operation (this is presumed to be the operation mode most commonly used in California's RCs). The three comparison configurations were: 1) The standard envelope and heat pump but constant fan operation during occupied hours, which shows the energy impact of constant outside air supplied at 315 CFM, or15 CFM/person as required by law in Title 24 (CCR, 1995). 2) The HPCBS envelope with the standard heat pump and a cycling fan, which shows the effect of the envelope measures alone, when compared to the base case. 3) The HPCBS envelope with the IDEC HVAC system, which shows the effect of the proposed package. Each of the four configurations were simulated in four climate zones with two occupancy schedules, resulting in 32 individual simulations. Climate zones 4 (San Jose), 11 (Red Bluff), 12 (Sacramento), and 13 (Fresno) were selected to represent energy use in the high growth areas of California (CEC, 2001). The two occupancy schedules representing typical year-round and traditional summer vacation schedules are further described below.

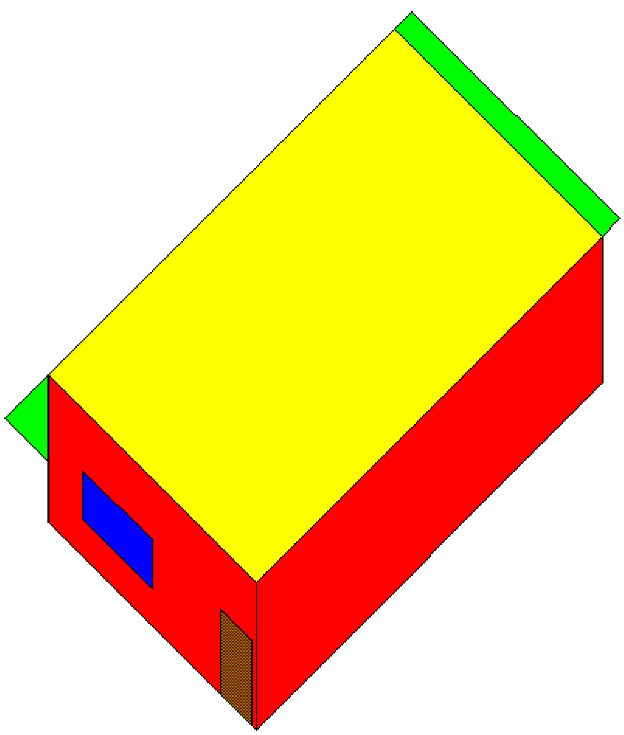
3.2 DOE2 Input File

Structural inputs were taken from working drawings provided by the manufacturer. Performance and operating inputs were developed using a combination of manufactures' data, interviews with school district maintenance personnel, monitored data obtained during previous PG&E RC projects (DEG, 2000), and engineering judgement. A listing of the input file is provided in Appendix A.

Loads

The loads input section is very simple; a graphical view of it is shown in Figure 3. All surfaces were modeled as layered constructions with custom weighting factors except the door which was modeled with a single R-value. The front and back overhangs are modeled as fixed building shades. K-3 occupancy (20 students and one teacher) is assumed with latent and sensible heat gains of 158 and 198 Btu/person respectively (75% of adult male, moderately active office work).

Figure 3: Graphical View of the DOE2 Loads Input



Inputs for the base case and HPCBS classrooms are compared in Table 2. The base case uses the standard insulation and equipment found in the manufacturers usual classroom specification, while the HPCBS classroom uses the PG&E Portable Efficient Relocatable Classroom (PERC) package one specifications plus a white coated roof.

Table 1: Comparison of Base Case and HPCBS Inputs

Input	*Base Case*	*HPCBS*
Wall Insulation R-value	11	13
Floor Insulation R-value	11	19
Roof Insulation R-value	19	19
GLASS-TYPE-CODE	2212 (grey tint)	2660 (selective surface)
Roof ABSORPTANCE	0.60 (bare metal)	0.25 (white coating)
Roof OUTSIDE-EMISS	0.50	0.95
LIGHTING-KW	1.66	0.75

Schedules

Although most schools use traditional schedules, a growing fraction use a year-round schedule; students attend school the same number of days as those on traditional schedules, but they get shorter breaks throughout the year (Chaika, 1999). Because year round operation has significantly more cooling season operation than traditional school schedules, two operating profiles were used for the simulations: year-round and traditional summer vacation. Both provide 180 days of occupancy but the year-round schedule consists of three three-month periods of occupancy separated by one-month breaks while the traditional schedule consists of a conventional school schedule of September though June with two-week breaks in spring and winter and a 2½ month summer vacation (see Figure 4). The weekday occupancy and lighting profiles used are shown in Figure 5. The daily lighting schedule is based on monitoring data from six RC's and includes the effect of bank switching, occupancy changes, and lights left on during non-occupied hours. The occupancy schedule used assumes full occupancy during class time, but both these schedules are expected to be revised based on monitoring data obtained from the HPCBS classrooms.

Figure 4: Annual Profiles for Seasonal and Full Year Operation

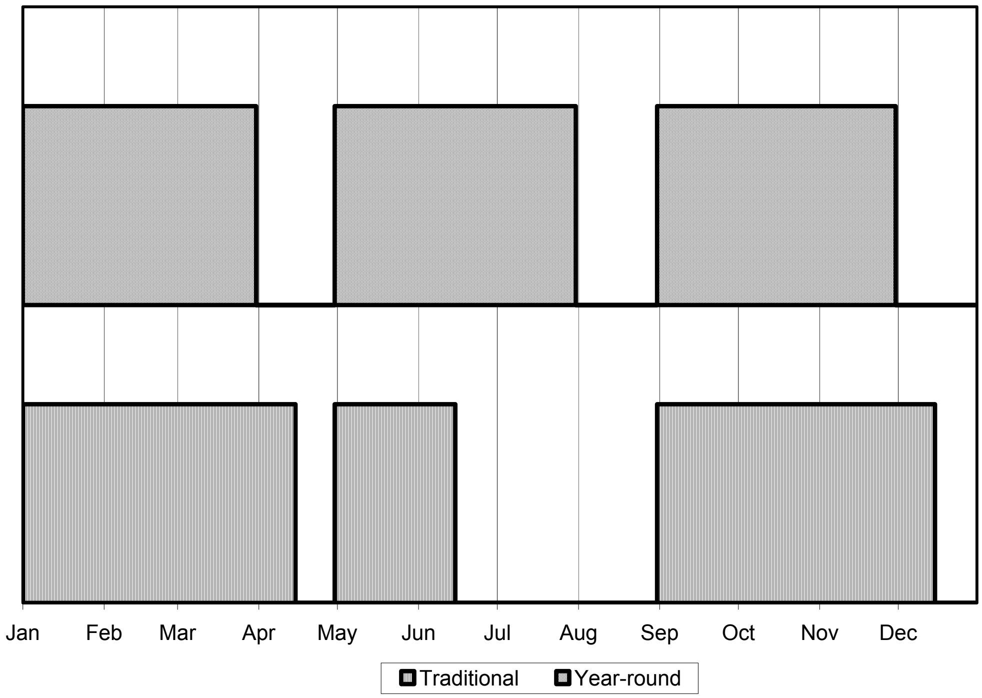
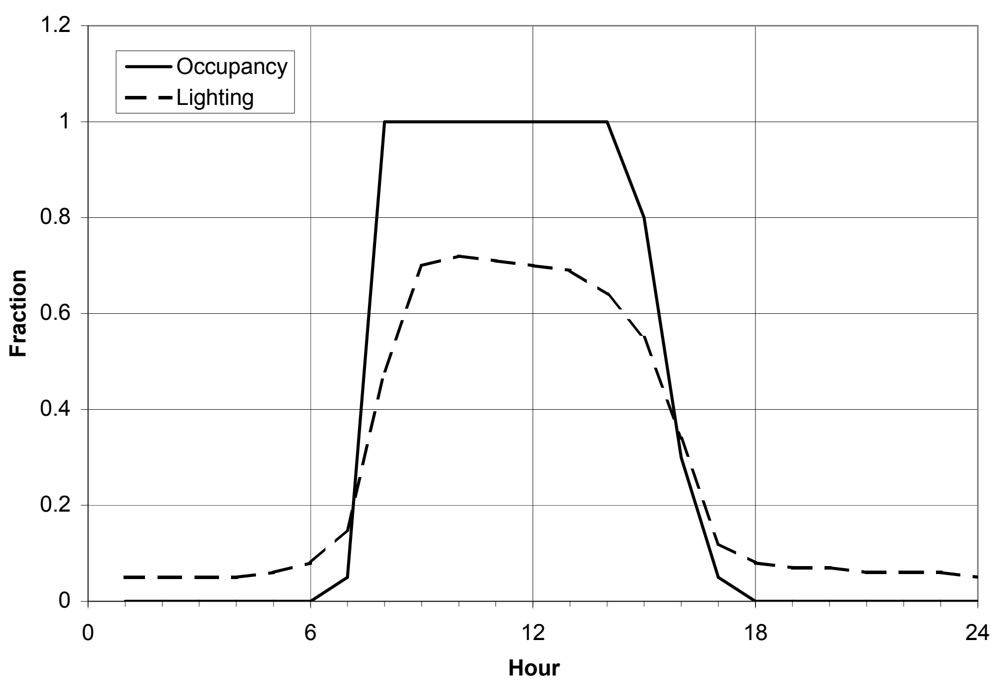


Figure 5: Weekday Profiles for Occupancy and Lighting



Systems

System operating assumptions such as set points, operating hours, and outside air ventilation rates, have the most significant effect on annual energy consumption of any DOE2 inputs and yet are the least well defined. RC HVAC equipment is controlled by a wall mounted thermostat that may have some communication with a central EMCS[3] but is typically set at the discretion of the teacher or custodian. Equipment may or may not be turned off during nights and weekends and setbacks may or may not be implemented. Outside air dampers are rarely set at the correct flow rate and the system fans are typically operated only during compressor operation resulting in no outside air ventilation when cooling or heating demand is satisfied. Finally, door and window use, which affect ventilation, are difficult to define.

Operating schedules and set points were developed using monitored data from six relocatable classrooms. Equipment (heating, cooling, and fans) were assumed to be available weekdays from 8am to 4pm with night operation enabled only if the set points were exceeded. The outside air flow rate was fixed at a total of 315 cfm which corresponds to the ASHRAE 62-99 requirement of 15 cfm/person (ASHRAE, 1999). The heating set point was set at 70°F from 8am to 4pm with a set back to 65°F at night and 60°F on the weekends. The cooling set point was set to a constant 76°F on weekdays and 85°F on weekends.

The inputs used for the base case 10 SEER wall-mount heat pump are summarized in Table 3. Custom efficiency, capacity, and part load curves were developed based on manufactures detailed data for a Bard WH482 (Bard, 2001).

Table 2: Base Case System Inputs

Input	*Value*
SYSTEM-TYPE	PSZ
HEAT-SOURCE	HEAT-PUMP
SUPPLY-FLOW	1400
FAN-CONTROL	CYCLING
SUPPLY-KW/FLOW	0.00032
INDOOR-FAN-MODE	INTERMITTENT
COOLING-CAPACITY	42000
COOLING-EIR	0.349
COOL-SH-CAP	33600
HEATING-EIR	0.4619

[3] Energy Management and Control System

Inputs for the HPCBS system are summarized in Table 3. The DOE2 stand-alone evaporative cooler model was used with the default effectiveness curves (in the next simulation phase detailed IDEC performance data from monitoring will be applied.) Variable fan speed functions are not available with the EVAP-COOL system type, so because fan power is critical to the performance of the IDEC system an external post processing program was used. Hourly output of indoor and outdoor temperatures, and heating and cooling loads were saved for each simulation. Since IDEC fan speed varies in proportion to the load, the fan air flow was adjusted using a linear correlation with heating and cooling part load. Fan air flow rate was calculated as follows:

Heating:

for Heat Load < 35,000 Btuh:

CFM = 315

for Heat Load > 35,000 Btuh:

CFM = 700

Cooling: Assume evaporative effectiveness = 1.0

CoolCap = 1.0 * (Tidb – Towb) * 1.08 * 1600

Where: Tidb = Indoor dry bulb temperature (°F)

Towb = Outdoor wet bulb temperature (°F)

CFM = max(315, CoolLoad/CoolCap * 1600)

Where: CoolLoad = hourly cooling load (Btuh)

315 = minimum air flow rate (cfm)

For ventilation (non-coincident with heating or cooling load), a constant airflow of 315 CFM during occupied hours was assumed. Since a 315 CFM airflow rate is sufficient to meet all heating loads except during morning warmup, winter fan air flow is fairly constant. The 35000 Btuh heating coil capacity corresponds to a 315 CFM airflow rate, and at higher airflows occurring during warmup the coil capacity will be higher and the run time shorter than calculated. The calculation of cooling fan energy use is similarly conservative, since effectiveness typically increases with decreasing airflow. Fan power use was calculated from the fan air flow rate using the following equation which was derived from data monitored during the testing of the IDEC unit at LBNL:

$$\text{Fan Power} = 14.07 * \text{CFM}^{0.000414*\text{CFM}}$$

The instantaneous water heater is modeled as a plant boiler with an HIR of 1.18 (85% efficiency) with no standby or jacket losses.

Table 3: HPCBS System Inputs

Input	*Value*
SYSTEM-TYPE	EVAP-COOL
EVAP-CL-TYPE	INDIRECT-DIRECT
DIRECT-EFF	0.90
INDIR-EFF	0.50
EVAP-CL-KW	0.00005
EVAP-CL+REC-RA	NO
HEATING-CAPACITY	-35000
HEAT-SOURCE	HOT-WATER
SUPPLY-CFM	1600
SUPPLY-KW/FLOW	0.0006
INDOOR-FAN-MODE	CONTINUOUS

4 Simulation Results

Because the base case design is all electric and the HPCBS package uses gas for heating, it is critical to use a well supported method of comparison that weights the gas and electricity use fairly. Two comparisons that lend themselves well to such fuel switching analyses are source energy use and utility costs.

Source energy use provides an indication of what the true total energy impact of an efficiency measure is. However, the conversion factor used to convert electricity into source energy can vary and depends on the aggregate fuel mix and the generation, transmission, and distribution efficiency of the utility providing the electricity. For this analysis we used an average heat rate of 10,239 Btu/kWh, the value used in the California energy efficiency standards, which assumes an aggregate transmission and distribution efficiency of 33% (Fernstrom, et. al., 2000).

Consumer utility costs are easily understood by building owners and equipment purchasers and are required for determining economic payback. However, utility rates have exhibited extreme volatility recently, with schedule G-NR1 natural gas rates varying by more than $1.00 per therm during 2001 and electric rates rising over 20%, making accurate projections of energy cost comparisons problematic. In addition, schools use various electric rate schedules ranging from small schools with simple tiered energy rates to large campuses with time-of-use energy and demand charges. To simplify the analysis we used blended electric and gas rates of $0.14 per kWh and $0.60 per therm to estimate utility costs.

A summary of all 32 runs including total source energy use and annual savings is presented in Table 4. Figure 6 shows a comparison of the source energy use for four different classroom configurations in Sacramento with traditional occupancy. Almost half of the base case building energy use is for lighting, more than one quarter is used for heating, and the remaining quarter is split between cooling and fan energy use.

When the fan is run constantly during occupancy the total energy use rises by 38%, due primarily to the fan energy use which more than triples. Heating and cooling energy use only rise by 25 and 12 percent respectively due to the mild conditions that exist most of the time when the compressor is not running.

When the base case building is upgraded with package 1 measures, lighting energy use is cut by more than half due to the reduction in lighting power density. Heating energy use remains virtually unchanged because the savings due to the better insulation levels is offset by the reduction in heat from the efficient lighting system. The cooling energy use, however, drops by almost half due to the combination of lower lighting power density and reduced glazing and envelope heat gains. Fan energy falls by 30% due to the reduced cooling operation.

Finally, when the base case heat pump is replaced by the IDEC/gas heat HVAC system, source heating energy use drops by 16% and cooling energy use is almost eliminated as the only energy use required by the IDEC in addition to fan energy is cooling pump energy. Fan energy use is cut by 60% due to the high efficiency of the electronically commutated variable speed motor, even though the fan now runs constantly during occupied hours to provide continuous outside air.

Table 4: Summary of DOE2 Simulation Results

System	Fan	CZ	Schedule	Envelope	Electric (kWh) Lights	Heating	Cooling	Fans & Pumps	Total	Gas Heating (therms)	Total Source (Mbtu[a])	Total Cost	Annual Savings Source (Mbtu[a])	Cost ($)	Energy (%)	Cost (%)
Heat Pump	Cycle	4	Seasonal	Base Case	2311	993	369	257	4009	0	41.0	$561				
Heat Pump	On	4	Seasonal	Base Case	2311	1099	428	1596	5492	0	56.2	$769	-15.2	-$208	-37%	-37%
Heat Pump	Cycle	4	Seasonal	Package 1	1044	984	156	142	2409	0	24.7	$337	16.4	$224	40%	40%
IDEC	On	4	Seasonal	Package 1	1044	51	4	100	1224	80	20.5	$219	20.5	$342	50%	61%
Heat Pump	Cycle	4	Year-round	Base Case	2409	694	598	560	4344	0	44.5	$608				
Heat Pump	On	4	Year-round	Base Case	2409	780	759	1798	5813	0	59.5	$814	-15.0	-$206	-34%	-34%
Heat Pump	Cycle	4	Year-round	Package 1	1088	683	289	505	2650	0	27.1	$371	17.3	$237	39%	39%
IDEC	On	4	Year-round	Package 1	1088	37	6	108	1260	58	18.7	$211	25.8	$397	58%	65%
Heat Pump	Cycle	11	Seasonal	Base Case	2311	1864	752	683	5731	0	58.7	$802				
Heat Pump	On	11	Seasonal	Base Case	2311	2073	984	2678	8132	0	83.3	$1,138	-24.6	-$336	-42%	-42%
Heat Pump	Cycle	11	Seasonal	Package 1	1044	1848	451	371	3838	0	39.3	$537	19.4	$265	33%	33%
IDEC	On	11	Seasonal	Package 1	1044	82	26	148	1326	136	27.2	$267	31.5	$535	54%	67%
Heat Pump	Cycle	11	Year-round	Base Case	2409	1331	1569	1064	6497	0	66.5	$910				
Heat Pump	On	11	Year-round	Base Case	2409	1504	2037	2739	8788	0	90.0	$1,230	-23.5	-$321	-35%	-35%
Heat Pump	Cycle	11	Year-round	Package 1	1088	1322	1092	888	4516	0	46.2	$632	20.3	$277	30%	30%
IDEC	On	11	Year-round	Package 1	1088	59	42	370	1579	100	26.2	$281	40.4	$629	61%	69%
Heat Pump	Cycle	12	Seasonal	Base Case	2311	1382	623	567	4994	0	51.1	$699				
Heat Pump	On	12	Seasonal	Base Case	2311	1552	776	2154	6874	0	70.4	$962	-19.2	-$263	-38%	-38%
Heat Pump	Cycle	12	Seasonal	Package 1	1044	1379	334	349	3220	0	33.0	$451	18.2	$248	36%	36%
IDEC	On	12	Seasonal	Package 1	1044	69	17	157	1314	112	24.7	$251	26.5	$448	52%	64%
Heat Pump	Cycle	12	Year-round	Base Case	2409	993	1165	925	5607	0	57.4	$785				
Heat Pump	On	12	Year-round	Base Case	2409	1129	1493	2327	7453	0	76.3	$1,043	-18.9	-$258	-33%	-33%
Heat Pump	Cycle	12	Year-round	Package 1	1088	988	727	798	3718	0	38.1	$521	19.3	$264	34%	34%
IDEC	On	12	Year-round	Package 1	1088	49	31	316	1505	81	23.5	$259	33.9	$526	59%	67%
Heat Pump	Cycle	13	Seasonal	Base Case	2311	1639	874	724	5659	0	57.9	$792				
Heat Pump	On	13	Seasonal	Base Case	2311	1867	1160	2637	8058	0	82.5	$1,128	-24.6	-$336	-42%	-42%
Heat Pump	Cycle	13	Seasonal	Package 1	1044	1623	498	394	3674	0	37.6	$514	20.3	$278	35%	35%
IDEC	On	13	Seasonal	Package 1	1044	72	28	186	1355	121	26.0	$262	32.0	$530	55%	67%
Heat Pump	Cycle	13	Year-round	Base Case	2409	1079	1698	1078	6379	0	65.3	$893				
Heat Pump	On	13	Year-round	Base Case	2409	1239	2229	2706	8679	0	88.9	$1,215	-23.5	-$322	-36%	-36%
Heat Pump	Cycle	13	Year-round	Package 1	1088	1065	1141	883	4295	0	44.0	$601	21.3	$292	33%	33%
IDEC	On	13	Year-round	Package 1	1088	50	46	407	1610	83	24.8	$275	40.5	$618	62%	69%

[a]Note: for comparison to other energy savings measures, 1 annual Mbtu source energy in a 960 ft^2 RC is equivalent to 1 $Kbtu \cdot ft^{-2} \cdot yr^{-1}$

Figure 6: Source Energy Use Comparison - Climate Zone 12, Traditional Occupancy.

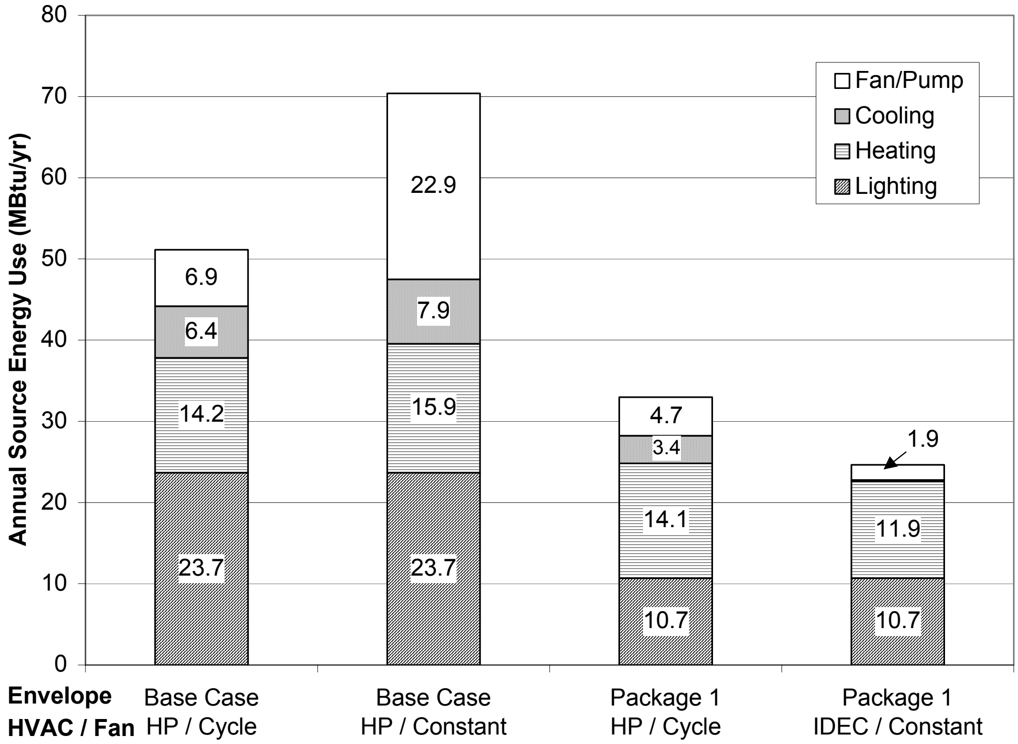


Figure 7 compares annual source energy savings for the HPCBS package vs. a base case envelope with the standard heat pump and a cycling fan in the four climate zones, and for the two operation schedules. Figure 8 similarly compares utility cost savings using the rates stated above.

Annual operating cost savings of from $342 to $535 for traditional occupancy, and from $397 to $629 for year-round occupancy were projected. Savings are the least for climate zone 4 and the greatest for climate zone 11. Clearly, these savings result from a combination of factors, including an improved building envelope, reduced lighting, elimination of compressor energy, fan energy reduction, and more favorable economics of gas heating compared to heat pump heating. Annual maintenance costs, which are likely to be higher for the IDEC system than for the heat pump, would probably degrade these savings by an as yet to be determined amount.

A comparison of operation Configuration 1, where ventilation is provided to the base case RC/HVAC package at 15 CFM/person as legally required, to the HPCBS RC/IDEC package Configuration 3 provides insight into the potential for savings when minimum RC ventilation requirements are met. In this case annual operating cost savings from the HPCBS package range from $550 to $871 for traditional occupancy, and from $603 to $950 for year-round occupancy were projected. Again, savings are the least for climate zone 4 and the greatest for climate zone 11.

Figure 7: Source Energy Savings for HPCBS Package vs. Base Case

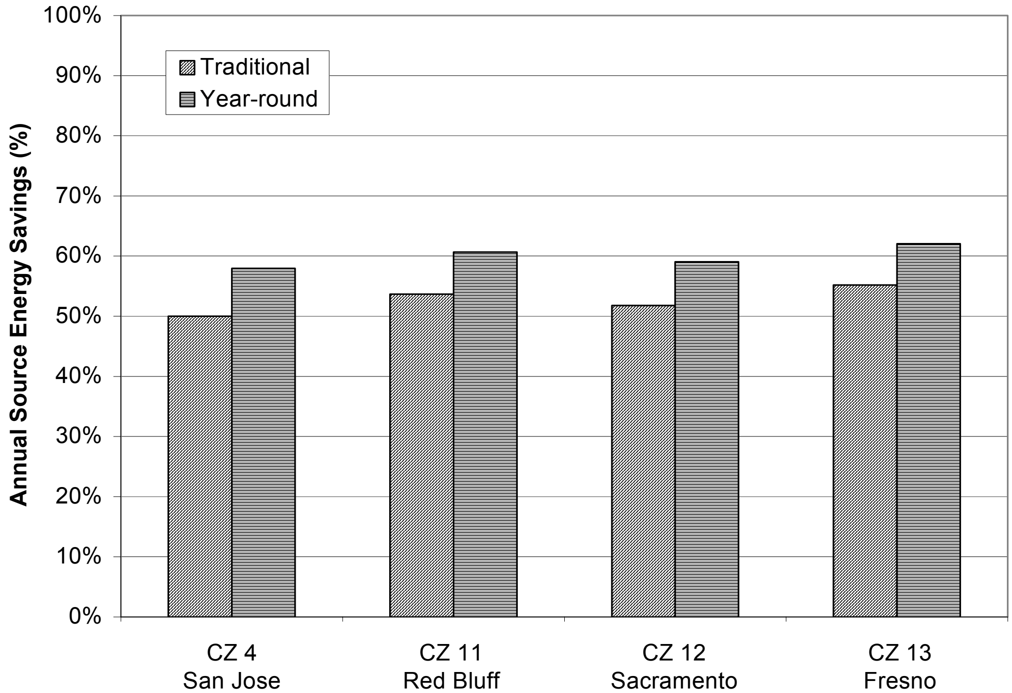
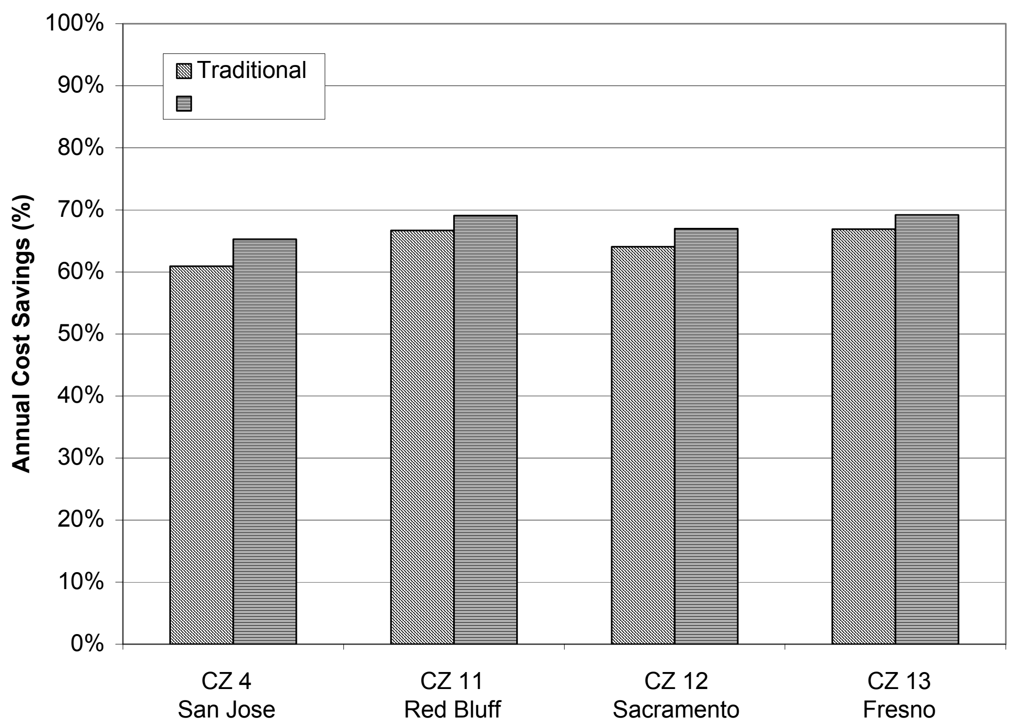


Figure 8: Utility Cost Savings for HPCBS Package vs Base Case



5 Conclusions

Simulations show very significant energy savings for the HPCBS package relative to the base case, suggesting a high probability of a short-term payback, depending of course on the incremental cost of the combined measures. Since envelope improvements are relatively transparent, most HPCBS package issues relate to mechanical systems, and to a lesser extent, lighting. Since the IDEC modeled and installed in the demonstration units is not currently on the market, installed costs and maintenance costs can only be roughly estimated, though field tests may yield useful data. Use of the IDEC could possibly lead to a degradation of comfort or other humidity-related issues resulting from the comparatively higher relative humidity provided from the direct component of the system.

HPCBS benefits that are likely to be recognized from field tests include substantially improved indoor air quality resulting from the 100% outside air heating and cooling air delivery; and reduced noise resulting from elimination of the compressor, lower fan speeds, and reduced heating and cooling demand. Field tests should yield information about occupant acceptability and maintenance requirements, as well as verify energy use and savings projections.

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Appendix A

DOE2 Input File Listing

```
INPUT LOADS ..

$*********************************************************
$       High Performance Building Systems Task 6
$           24x40 Modular Classroom Building
$         Author: Leo Rainer, Davis Energy Group
$                      2/14/01
$*********************************************************

$ --------------------------------------------------------
$              Macros
$ --------------------------------------------------------
##include ..\run.inc

##if #[shell[] eqs "B"]  $ base case conditions
       ##set1 light  1.66
       ##set1 glass  "2212"     $ grey tint
       ##set1 wallr  "IN11"
       ##set1 floorr "IN11"
       ##set1 absorp 0.6               $ bare standing seam
       ##set1 emiss  0.5
##elseif #[shell[] eqs "1"]  $ PERC package 1 envelope + white roof
       ##set1 light  0.750
       ##set1 glass  "2660"     $ selective surface
       ##set1 wallr  "IN13"     $ R13 wall
       ##set1 floorr "IN12"     $ R19 floor
       ##set1 absorp 0.25       $ white roof
       ##set1 emiss  0.95
##endif

##if #[hvac[] eqs "HP10"]   $ base BARD unit
   ##if #[#[cz[] eqs "CZ11"] OR #[cz[] eqs "CZ13"]]
          ##set1 ccap    56500   $ WH602
               ##set1 shcap   39900
       ##set1 fancfm  1700
   ##elseif #[#[cz[] eqs "CZ12"] OR #[cz[] eqs "CZ02"]]
          ##set1 ccap    47000   $ WH482
               ##set1 shcap   36000
       ##set1 fancfm  1550
       ##else
          ##set1 ccap    41500   $ WH421
               ##set1 shcap   32600
       ##set1 fancfm  1400
       ##endif
       ##set1 hcap    42880
   ##set1 fankw   0.00036
   ##set1 strip   -34000  $ 10kw of strip
   ##set1 ceir    0.325         $ at 95 with fan heat removed
       ##set1 heir       0.305   $ at 47 with fan heat removed
   ##set1 fan cycle    $ default to cycle for now
##elseif #[hvac[] eqs "HP12"] $ 12 SEER wall hung
   ##set1 fankw   0.00019
   ##set1 ceir    0.28
       ##set1 heir       0.37
   ##set1 fan cycle    $ default to cycle for now
##elseif #[hvac[] eqs "IDEC"] $ HPBS idec spec
       ##set1 fan on
##endif

##if #[sched[] eqs "P"]    $ partial year (summer vacation)
       ##set1 occ_sched              OCC-PART
       ##set1 light_sched     LIGHT-PART
       ##set1 heat_sched             HEAT-PART
```

```
       ##set1 cool_sched             COOL-PART
       ##set1 fan_sched              FAN-PART
       ##set1 hvac_sched             ON-PART
##else                                              $ full year (year round)
       ##set1 occ_sched              OCC-FULL
       ##set1 light_sched    LIGHT-FULL
       ##set1 heat_sched             HEAT-FULL
       ##set1 cool_sched             COOL-FULL
       ##set1 fan_sched              FAN-FULL
       ##set1 hvac_sched             ON-FULL
##endif

##if #[fan[] eqs "cycle"]         $ cycling indoor fan
   ##set1 fan_mode  INTERMITTENT
   ##set1 fan_sched FAN-OFF
       ##set1 econo   FIXED
       ##set1 leak   0.0005
##elseif #[fan[] eqs "on"]        $ indoor fan always on
   ##set1 fan_mode  CONTINUOUS
       ##set1 econo   FIXED
       ##set1 leak   0
##elseif #[fan[] eqs "econo"]  $ economizer
   ##set1 fan_mode  CONTINUOUS
       ##set1 econo   TEMP
       ##set1 leak   0
##endif

##set1 people  21                $ occupants
##set1 osa     315            $ outside air

$ ---------------------------------------------------------
$              Title, Run Periods, Design Days, Holidays
$ ---------------------------------------------------------

TITLE
   LINE-1           = *HPBS 24x40 Modular Classroom*
   LINE-2           = run_title[]
       LINE-3           = cz[]
   ..

ABORT ERRORS  ..
LIST WARNINGS NO-LIMITS              ..
RUN-PERIOD JAN 1 2000 THRU DEC 31 2000      ..
BUILDING-LOCATION
   AZIMUTH   = 270           $  direction front door is facing (W = worst case)
       ..
         LOADS-REPORT
$          VERIFICATION (LV-A,LV-B,LV-C,LV-D,LV-E,LV-F,LV-G,LV-H,LV-I,LV-J,LV-K)
           VERIFICATION (LV-D,LV-F)
           SUMMARY=(LS-E,LS-F)
           HOURLY-DATA-SAVE=FORMATTED ..


$ ---------------------------------------------------------
$              Materials / Layers / Constructions
$ ---------------------------------------------------------


WALLAY = LAYERS
   MATERIAL         = ( PW03, wallr[], GP02)
   INSIDE-FILM-RES=.68
   ..
ROOFLAY = LAYERS
   MATERIAL         = ( AS01, IN03, AL33, AC02)
   INSIDE-FILM-RES=.765
   ..
FLOORLAY = LAYERS
   MATERIAL         = ( floorr[], PW05, CP02)
   INSIDE-FILM-RES=.765
   ..
```

```
WALLCON = CONSTRUCTION
   ABSORPTANCE      = 0.50
   LAYERS           = WALLAY
   ..
ROOFCON = CONSTRUCTION
   ABSORPTANCE      = absorp[]
   LAYERS           = ROOFLAY
   ..
FLOORCON = CONSTRUCTION
   LAYERS           = FLOORLAY
   ..
DOORCON  = CONSTRUCTION  $ solid ureth. door wo/T-B
      U-VALUE=.40 ..

$ ---------------------------------------------------------
$              Glass Types
$ ---------------------------------------------------------

WINDOWCON = GLASS-TYPE
   GLASS-TYPE-CODE  = glass[]
   $FRAME-CONDUCTANCE = FRAMECON
  ..


$ ---------------------------------------------------------
$              Day Schedules
$ ---------------------------------------------------------

OCC-WD = DAY-SCHEDULE
           HOURS = (1,7)     VALUES = (0)
           HOURS = (8)       VALUES = (.05)
           HOURS = (9,14)    VALUES = (1)
           HOURS = (15)      VALUES = (.8)
           HOURS = (16)      VALUES = (.30)
           HOURS = (17)      VALUES = (.05)
           HOURS = (18,24)   VALUES = (0)
   ..
OCC-WE = DAY-SCHEDULE
   (1,24) ( 0 )
   ..
LIGHT-WD = DAY-SCHEDULE
   (1,24) ( 0.05,0.05,0.05,0.05,0.06,0.08,0.15,0.48,0.70,0.72,0.71,
              0.70,0.69,0.64,0.55,0.34,0.12,0.08,0.07,0.07,0.06,0.06,0.06,0.05)
   ..
LIGHT-WE = DAY-SCHEDULE
   (1,24) ( 0.05 )
   ..

$ ---------------------------------------------------------
$              Week Schedules
$ ---------------------------------------------------------

OCC-WEEK = WEEK-SCHEDULE
            DAYS    (WD)         DAY-SCHEDULE = OCC-WD
            DAYS    (WEH)        DAY-SCHEDULE = OCC-WE
   ..

OCC-WEEK-OFF = WEEK-SCHEDULE
            DAYS    (ALL)        DAY-SCHEDULE = OCC-WE
   ..

LIGHT-WEEK = WEEK-SCHEDULE
            DAYS    (WD)         DAY-SCHEDULE = LIGHT-WD
            DAYS    (WEH)        DAY-SCHEDULE = LIGHT-WE
   ..

LIGHT-WEEK-OFF = WEEK-SCHEDULE
            DAYS    (ALL)        DAY-SCHEDULE = LIGHT-WE
   ..

$ ---------------------------------------------------------
```

```
$              Annual Schedules
$ ---------------------------------------------------------

LIGHT-PART = SCHEDULE
           THRU APR 30          WEEK-SCHEDULE = LIGHT-WEEK
           THRU MAY 15          WEEK-SCHEDULE = LIGHT-WEEK-OFF
           THRU JUN 15          WEEK-SCHEDULE = LIGHT-WEEK
           THRU AUG 31          WEEK-SCHEDULE = LIGHT-WEEK-OFF
           THRU DEC 15          WEEK-SCHEDULE = LIGHT-WEEK
           THRU DEC 31          WEEK-SCHEDULE = LIGHT-WEEK-OFF
   ..

LIGHT-FULL = SCHEDULE
           THRU MAR 31          WEEK-SCHEDULE = LIGHT-WEEK
           THRU APR 30          WEEK-SCHEDULE = LIGHT-WEEK-OFF
           THRU JUL 31          WEEK-SCHEDULE = LIGHT-WEEK
           THRU AUG 31          WEEK-SCHEDULE = LIGHT-WEEK-OFF
           THRU NOV 30          WEEK-SCHEDULE = LIGHT-WEEK
           THRU DEC 31          WEEK-SCHEDULE = LIGHT-WEEK-OFF
   ..

OCC-PART = SCHEDULE
           THRU APR 30          WEEK-SCHEDULE = OCC-WEEK
           THRU MAY 15          WEEK-SCHEDULE = OCC-WEEK-OFF
           THRU JUN 15          WEEK-SCHEDULE = OCC-WEEK
           THRU AUG 31          WEEK-SCHEDULE = OCC-WEEK-OFF
           THRU DEC 15          WEEK-SCHEDULE = OCC-WEEK
           THRU DEC 31          WEEK-SCHEDULE = OCC-WEEK-OFF
   ..

OCC-FULL = SCHEDULE
           THRU MAR 31          WEEK-SCHEDULE = OCC-WEEK
           THRU APR 30          WEEK-SCHEDULE = OCC-WEEK-OFF
           THRU JUL 31          WEEK-SCHEDULE = OCC-WEEK
           THRU AUG 31          WEEK-SCHEDULE = OCC-WEEK-OFF
           THRU NOV 30          WEEK-SCHEDULE = OCC-WEEK
           THRU DEC 31          WEEK-SCHEDULE = OCC-WEEK-OFF
   ..


$ *********************************************************
$ **                                                     **
$ **      Floors / Spaces / Walls / Windows / Doors      **
$ **                                                     **
$ *********************************************************


CLASSRM = SPACE
       AREA             = 960
   VOLUME           = 11520           $ includes ceiling plenum
   TEMPERATURE      = (74)
   PEOPLE-SCHEDULE  = occ_sched[]
   LIGHTING-SCHEDUL = light_sched[]
   LIGHTING-TYPE    = REC-FLUOR-NV
   PEOPLE-HG-LAT    = 158             $ 75% of Adult male, Moderatly active office work
   PEOPLE-HG-SENS   = 198
   LIGHTING-KW      = light[]
   NUMBER-OF-PEOPLE = people[]
   DAYLIGHTING      = NO
   INF-METHOD       = S-G
   HOR-LEAK-FRAC    = 0.3
   FRAC-LEAK-AREA   = leak[]
   FLOOR-WEIGHT     = 0
   ..

FRONTSH = BUILDING-SHADE
   HEIGHT           = 5
       WIDTH            = 24
       X                = 0
       Y                = 0
       Z                = 12
```

```
        TILT              = 180
        AZIMUTH           = 180
        ..
BACKSH = BUILDING-SHADE
   HEIGHT            = 2
        WIDTH             = 24
        X                 = 24
        Y                 = 40
        Z                 = 12
        TILT              = 180
        AZIMUTH           = 0
        ..
FRONTW = EXTERIOR-WALL
   CONSTRUCTION      = WALLCON
        HEIGHT            = 12
   WIDTH             = 24
        X                 = 0
        Y                 = 0
        AZIMUTH           = 180
   ..
FWINDOW = WINDOW
   GLASS-TYPE        = WINDOWCON
   X                 = 4
   Y                 = 3
   HEIGHT            = 4
   WIDTH             = 8
   ..
FDOOR = DOOR
   CONSTRUCTION      = DOORCON
   X                 = 20
   HEIGHT            = 7
   WIDTH             = 3.5
   ..

BACKW = EXTERIOR-WALL
   LIKE FRONTW
        X                 = 24
        Y                 = 40
        AZIMUTH           = 0
   ..
BWINDOW = WINDOW
   GLASS-TYPE        = WINDOWCON
   X                 = 4
   Y                 = 3
   HEIGHT            = 4
   WIDTH             = 8
   ..

RIGHTW = EXTERIOR-WALL
   CONSTRUCTION      = WALLCON
        HEIGHT            = 12
   WIDTH             = 40
        X                 = 24
        Y                 = 0
        AZIMUTH           = 90
   ..

LEFTW = EXTERIOR-WALL
   LIKE RIGHTW
        X                 = 0
        Y                 = 40
        AZIMUTH           = 270
   ..

ROOF-1 = ROOF
   CONSTRUCTION      = ROOFCON
   HEIGHT            = 40
   WIDTH             = 24
        X                 = 0
        Y                 = 0
        Z                 = 12
```

```
        AZIMUTH          = 180
        TILT             = 0
        OUTSIDE-EMISS    = emiss[]
    ..

FLOOR-1 = EXTERIOR-WALL
   CONSTRUCTION     = FLOORCON
   HEIGHT           = 40
   WIDTH            = 24
        X                = 0
   Y                = 40
        Z                = 0
        AZIMUTH          = 180
        TILT             = 180
    ..

END ..

COMPUTE LOADS ..

INPUT SYSTEMS ..

##ifdef func[]
     SUBR-FUNCTIONS
          VARVOL-0=*SETSPEED*
          VARVOL-1Z=*ADDLOAD*
          VARVOL-2=*SAVETEMP*
          VARVOL-3=*SAVELOAD*
          ..
##endif

$ ----------------------------------------------------------
$              Day Schedules
$ ----------------------------------------------------------

COOL-STAT-ON = DAY-SCHEDULE
   (1,24) ( 76 )
   ..
COOL-STAT-OFF = DAY-SCHEDULE
   (1,24) ( 85 )
   ..
FAN-ON-DAY = DAY-SCHEDULE
           HOURS = (1,7)      VALUES = (0)
           HOURS = (8,16)     VALUES = (1)
           HOURS = (17,24)    VALUES = (0)
   ..
FAN-OFF-DAY = DAY-SCHEDULE
   (1,24) ( 0 )
   ..
HEATING-STAT-ON = DAY-SCHEDULE
           HOURS = (1,7)      VALUES = (65)
           HOURS = (8,16)     VALUES = (70)
           HOURS = (17,24)    VALUES = (65)
   ..
HEATING-STAT-OFF = DAY-SCHEDULE
   (1,24) ( 60 )
   ..
ON-DAY = DAY-SCHEDULE
   (1,24) ( 1 )
   ..
OFF-DAY = DAY-SCHEDULE
   (1,24) ( 0 )
   ..

$ ----------------------------------------------------------
$              Week Schedules
$ ----------------------------------------------------------

ON-WEEK = WEEK-SCHEDULE
            DAYS    (ALL)         DAY-SCHEDULE = ON-DAY
        ..
```

```
OFF-WEEK = WEEK-SCHEDULE
            DAYS    (ALL)         DAY-SCHEDULE = OFF-DAY
        ..
FAN-OFF-WEEK = WEEK-SCHEDULE
            DAYS    (ALL)         DAY-SCHEDULE = FAN-OFF-DAY
   ..
FAN-ON-WEEK = WEEK-SCHEDULE
            DAYS    (WD)         DAY-SCHEDULE = FAN-ON-DAY
            DAYS    (WEH)        DAY-SCHEDULE = FAN-OFF-DAY

   ..
HEAT-WINTER-WEEK = WEEK-SCHEDULE
            DAYS    (WD)         DAY-SCHEDULE = HEATING-STAT-ON
            DAYS    (WEH)        DAY-SCHEDULE = HEATING-STAT-OFF
   ..
HEAT-SUMMER-WEEK = WEEK-SCHEDULE
            DAYS    (ALL)         DAY-SCHEDULE = HEATING-STAT-OFF
   ..
HEAT-WEEK-OFF = WEEK-SCHEDULE
            DAYS    (ALL)         DAY-SCHEDULE = HEATING-STAT-OFF
   ..
COOL-SUMMER-WEEK = WEEK-SCHEDULE
            DAYS    (WD)         DAY-SCHEDULE = COOL-STAT-ON
            DAYS    (WEH)        DAY-SCHEDULE = COOL-STAT-OFF
   ..
COOL-WINTER-WEEK = WEEK-SCHEDULE
            DAYS    (ALL)         DAY-SCHEDULE = COOL-STAT-OFF
   ..
COOL-WEEK-OFF = WEEK-SCHEDULE
            DAYS    (ALL)         DAY-SCHEDULE = COOL-STAT-OFF
   ..

$ ---------------------------------------------------------
$              Annual Schedules
$ ---------------------------------------------------------


HEAT-PART = SCHEDULE
           THRU APR 30          WEEK-SCHEDULE = HEAT-WINTER-WEEK
           THRU MAY 15          WEEK-SCHEDULE = HEAT-WEEK-OFF
           THRU JUN 15          WEEK-SCHEDULE = HEAT-SUMMER-WEEK
           THRU AUG 31          WEEK-SCHEDULE = HEAT-WEEK-OFF
           THRU SEP 30          WEEK-SCHEDULE = HEAT-SUMMER-WEEK
           THRU DEC 15          WEEK-SCHEDULE = HEAT-WINTER-WEEK
           THRU DEC 31          WEEK-SCHEDULE = HEAT-WEEK-OFF
                         ..
HEAT-FULL = SCHEDULE
           THRU MAR 31          WEEK-SCHEDULE = HEAT-WINTER-WEEK
           THRU APR 30          WEEK-SCHEDULE = HEAT-WEEK-OFF
           THRU JUL 31          WEEK-SCHEDULE = HEAT-SUMMER-WEEK
           THRU AUG 31          WEEK-SCHEDULE = HEAT-WEEK-OFF
           THRU SEP 30          WEEK-SCHEDULE = HEAT-SUMMER-WEEK
           THRU NOV 30          WEEK-SCHEDULE = HEAT-WINTER-WEEK
           THRU DEC 31          WEEK-SCHEDULE = HEAT-WEEK-OFF
                         ..

COOL-PART = SCHEDULE
           THRU APR 30          WEEK-SCHEDULE = COOL-WINTER-WEEK
           THRU MAY 15          WEEK-SCHEDULE = COOL-WEEK-OFF
           THRU JUN 15          WEEK-SCHEDULE = COOL-SUMMER-WEEK
           THRU AUG 31          WEEK-SCHEDULE = COOL-WEEK-OFF
           THRU SEP 30          WEEK-SCHEDULE = COOL-SUMMER-WEEK
           THRU DEC 15          WEEK-SCHEDULE = COOL-WINTER-WEEK
           THRU DEC 31          WEEK-SCHEDULE = COOL-WEEK-OFF
                         ..
COOL-FULL = SCHEDULE
           THRU MAR 31          WEEK-SCHEDULE = COOL-WINTER-WEEK
           THRU APR 30          WEEK-SCHEDULE = COOL-WEEK-OFF
           THRU JUL 31          WEEK-SCHEDULE = COOL-SUMMER-WEEK
           THRU AUG 31          WEEK-SCHEDULE = COOL-WEEK-OFF
           THRU SEP 30          WEEK-SCHEDULE = COOL-SUMMER-WEEK
           THRU NOV 30          WEEK-SCHEDULE = COOL-WINTER-WEEK
```

```
           THRU DEC 31          WEEK-SCHEDULE = COOL-WEEK-OFF
                        ..

FAN-PART = SCHEDULE
           THRU APR 30          WEEK-SCHEDULE = FAN-ON-WEEK
           THRU MAY 15          WEEK-SCHEDULE = FAN-OFF-WEEK
           THRU JUN 15          WEEK-SCHEDULE = FAN-ON-WEEK
           THRU AUG 31          WEEK-SCHEDULE = FAN-OFF-WEEK
           THRU DEC 15          WEEK-SCHEDULE = FAN-ON-WEEK
           THRU DEC 31          WEEK-SCHEDULE = FAN-OFF-WEEK
                        ..
FAN-FULL = SCHEDULE
           THRU MAR 31          WEEK-SCHEDULE = FAN-ON-WEEK
           THRU APR 30          WEEK-SCHEDULE = FAN-OFF-WEEK
           THRU JUL 31          WEEK-SCHEDULE = FAN-ON-WEEK
           THRU AUG 31          WEEK-SCHEDULE = FAN-OFF-WEEK
           THRU NOV 30          WEEK-SCHEDULE = FAN-ON-WEEK
           THRU DEC 31          WEEK-SCHEDULE = FAN-OFF-WEEK
                        ..
FAN-OFF = SCHEDULE
           THRU DEC 31          WEEK-SCHEDULE = FAN-OFF-WEEK
   ..

ON-PART = SCHEDULE
           THRU JUN 15          WEEK-SCHEDULE = ON-WEEK
           THRU AUG 31          WEEK-SCHEDULE = OFF-WEEK
           THRU DEC 31          WEEK-SCHEDULE = ON-WEEK
   ..
ON-FULL = SCHEDULE
           THRU MAR 31          WEEK-SCHEDULE = ON-WEEK
           THRU APR 30          WEEK-SCHEDULE = OFF-WEEK
           THRU JUL 31          WEEK-SCHEDULE = ON-WEEK
           THRU AUG 31          WEEK-SCHEDULE = OFF-WEEK
           THRU NOV 30          WEEK-SCHEDULE = ON-WEEK
           THRU DEC 31          WEEK-SCHEDULE = OFF-WEEK
   ..
ON-ALL = SCHEDULE
           THRU DEC 31          WEEK-SCHEDULE = ON-WEEK
   ..

$ *******************************************************
$ **                                                   **
$ **               Performance Curves                  **
$ **                                                   **
$ *******************************************************


$ --------------------------------------------------------
$             Curve Fits
$ --------------------------------------------------------

$------------ BARD WH482 -----------
$ Capacity
COOL-CAP-WH48 = CURVE-FIT
   TYPE             = BI-QUADRATIC
   COEFFICIENTS     = (-2.29821768,0.00330886,0.00002091,
                            0.08354232,-0.00027935,-0.00024323)
   ..
$ Sensible Capacity
COOL-SHCAP-WH48 = CURVE-FIT
   TYPE             = BI-QUADRATIC
   COEFFICIENTS     = (-2.37664761,-0.00107246,0.00000543,
                             0.11007952,-0.00078588,-0.00006567)
   ..
$ Efficiency  (from SEER 10)
COOL-EIR-WH48 = CURVE-FIT
   TYPE             = BI-QUADRATIC
   COEFFICIENTS     = (-0.08082241,0.02463397,-0.00019230,
                       -0.00350821,0.00008021,-0.00001524)
..
$ Heating Capacity
```

```
HEAT-CAP-WH48 = CURVE-FIT
   TYPE             = CUBIC
   COEFFICIENTS     = (0.48812796,-0.00214259,0.00040737,-0.00000277)
   ..
$ HEIR
HEAT-EIR-WH48 = CURVE-FIT
   TYPE             = CUBIC
   COEFFICIENTS     = (1.73818534,-0.00900801,-0.00031053,0.00000357)
   ..



$------------ EIR/HIR-FPLR CURVES -----------
$From Danny Parker, FSEC, 1998
$Heat/Cool FPLR for AC cool and HP heat/cool

PLR-EIR-RESYS = CURVE-FIT
   TYPE             = CUBIC
   COEFFICIENTS     = ( 0.0101858, 1.18131, -0.246748, 0.055574)
   ..

PLR-EIR-GHP = CURVE-FIT
   TYPE             = CUBIC
   COEFFICIENTS     = ( 0.00988125, 1.08033, -0.105267, 0.0151403)
   ..

PLR-HIR-RESYS-FR = CURVE-FIT
   TYPE             = CUBIC
   COEFFICIENTS     = ( 0.01177125, 0.98061775, 0.11783017, -0.11032275)
   ..

PLR-HIR-RESYS-FC = CURVE-FIT
   TYPE             = CUBIC
   COEFFICIENTS     = ( 0.00804726, 0.87564457, 0.29249943, -0.17624156)
   ..


"SDL-C20-NEW" = CURVE-FIT
   TYPE             = LINEAR
   COEFFICIENTS     = ( 0.0833, 0.9167 )
   ..

"SDL-C25-NEW" = CURVE-FIT
   TYPE             = BI-QUADRATIC
   COEFFICIENTS     = ( 0.392305, 0.011888, 0, -0.00080916, 0, -2.452e-005 )
   ..

"SDL-C65-NEW" = CURVE-FIT
   TYPE             = LINEAR
   COEFFICIENTS     = ( 0.0833, 0.9167 )
   ..

"GAS-FURN-PLR" = CURVE-FIT
   TYPE             = QUADRATIC
   COEFFICIENTS     = ( 0.018610,1.094209,-0.112819 )
   ..

$ **********************************************************
$ **                                                      **
$ **               HVAC Systems / Zones                   **
$ **                                                      **
$ **********************************************************

CLASSRM = ZONE
   ZONE-TYPE        = CONDITIONED
        DESIGN-HEAT-T    = 70
   DESIGN-COOL-T    = 76
   OUTSIDE-AIR-FLOW = osa[]
   HEAT-TEMP-SCH    = heat_sched[]
   COOL-TEMP-SCH    = cool_sched[]
   ..
```

```
##if #[hvac[] eqs "IDEC"]
SYS-1 = SYSTEM
   SYSTEM-TYPE      = EVAP-COOL
        ZONE-NAMES       =(CLASSRM)
        EVAP-CL-TYPE     = INDIRECT-DIRECT
        DIRECT-EFF       = 0.90                 $ CelDek
        INDIR-EFF        = 0.50                 $ Adobe HX performance for now
        EVAP-CL-KW       = .00005       $ 80W / 1600cfm pump, single fan
        EVAP-CL+REC-RA   = NO
        HEATING-CAPACITY = -35000       $ hydronic coil
   HEAT-SOURCE      = HOT-WATER
   HEATING-SCHEDULE = hvac_sched[]
   COOLING-SCHEDULE = hvac_sched[]
   SUPPLY-CFM       = 1600
        MIN-OUTSIDE-AIR  = osa[]
   FAN-SCHEDULE     = fan_sched[]
   SUPPLY-KW/FLOW   = 0.0006    $ 1kw/1600cfm
        FAN-CONTROL      = SPEED        $ ECM
        MIN-FAN-RATIO    = 0.1
   NIGHT-CYCLE-CTRL = CYCLE-ON-ANY
   INDOOR-FAN-MODE  = fan_mode[]
   ..
##else
SYS-1 = SYSTEM
   SYSTEM-TYPE      = PSZ
        ZONE-NAMES       =(CLASSRM)
   HEAT-SOURCE      = HEAT-PUMP
   HEATING-SCHEDULE = hvac_sched[]
   COOLING-SCHEDULE = hvac_sched[]
   SUPPLY-FLOW      = fancfm[]
   FAN-SCHEDULE     = fan_sched[]
   FAN-CONTROL      = CYCLING
   SUPPLY-KW/FLOW   = fankw[]
   NIGHT-CYCLE-CTRL = CYCLE-ON-ANY
   INDOOR-FAN-MODE  = fan_mode[]
   COOLING-CAPACITY = ccap[]
   COOLING-EIR      = ceir[]
   COOL-SH-CAP      = shcap[]
        $HEATING-CAPACITY = hcap[]
   HEATING-EIR      = heir[]
        OA-CONTROL       = econo[]
        ECONO-LOCKOUT    = NO
        HEAT-CAP-FT      = HEAT-CAP-WH48
        HEAT-EIR-FT      = HEAT-EIR-WH48
        COOL-CAP-FT      = COOL-CAP-WH48
        COOL-SH-FT       = COOL-SHCAP-WH48
        COOL-EIR-FT      = COOL-EIR-WH48
        COOL-EIR-FPLR    = PLR-EIR-RESYS
        HEAT-EIR-FPLR    = PLR-EIR-RESYS
        HP-SUPP-SOURCE   = ELECTRIC
        HP-SUPP-HT-CAP   = strip[]
        DEFROST-TYPE     = REVERSE-CYCLE
   ..
##endif

PLANT1 = PLANT-ASSIGNMENT
   SYSTEM-NAMES = (SYS-1)
   ..

$ ----------------------------------------------------------
$              Hourly Reporting
$ ----------------------------------------------------------
SYSTEMS-REPORT
          HOURLY-DATA-SAVE=FORMATTED
     VERIFICATION (SV-A)
     SUMMARY=(SS-A,SS-F,SS-H)
          ..

##if #[hvac[] eqs "IDEC"]
BLOCK-1 = REPORT-BLOCK
```

```
   VARIABLE-TYPE    = GLOBAL
   VARIABLE-LIST    = ( 7,8 ) $ WBT, DBT
   ..
BLOCK-2 = REPORT-BLOCK
   VARIABLE-TYPE    = CLASSRM
   VARIABLE-LIST    = ( 6 ) $ TNOW
   ..
BLOCK-3 = REPORT-BLOCK
   VARIABLE-TYPE    = SYS-1
   VARIABLE-LIST    = ( 5,6,33 ) $ heat, cool, fan
   ..


RPT-1 = HOURLY-REPORT
  REPORT-SCHEDULE  = ON-ALL
  REPORT-BLOCK     = ( BLOCK-1, BLOCK-2, BLOCK-3 )
  ..
##endif

END ..

COMPUTE SYSTEMS ..

INPUT PLANT ..

$ Rinnai PLR curve
HW-PLR-RINNAI = CURVE-FIT
   TYPE             = LINEAR
   COEFFICIENTS     = (0.01,1)  $ instantaneous - no degradation
   ..


PLANT1 = PLANT-ASSIGNMENT  ..

          PLANT-REPORT        SUMMARY=(BEPU,PS-B) ..

##if #[hvac[] eqs "IDEC"]
   PLANT-PARAMETERS
          HW-BOILER-HIR       = 1.18
                        E-HW-BOILER-LOSS    = 0
                        HCIRC-DESIGN-T-DROP = 20
                        HCIRC-HEAD          = 24
                        HCIRC-IMPELLER-EFF  = 0.77
                        HCIRC-LOSS          = 0
                        HCIRC-MOTOR-EFF     = 0.7
                        ..

       EQUIPMENT-QUAD
                        HW-BOILER-HIR-FPLR  = HW-PLR-RINNAI
                        ..

   BOILER1         = PLANT-EQUIPMENT
         TYPE             = HW-BOILER
         INSTALLED-NUMBER = 1
         MAX-NUMBER-AVAIL = 1
         SIZE             = 0.04  ..  $ set small now to reduce plr loss (should put in
new curve)

                       PART-LOAD-RATIO
                       TYPE             = HW-BOILER
                       $MIN-RATIO        = 0
                       MAX-RATIO        = 1
                       ELEC-INPUT-RATIO = 0.007      $ 80W/40KBTU
                       ..
##endif

END ..
COMPUTE PLANT ..

STOP ..
```